Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Hand Auger Borings

SOP ID: 10003
Date Initiated: 02/20/90
Revision No. 007: 05/15/02

Approved By: ***/s/ David E. Lehnus*** ***05/21/02***
David E. Lehnus **Date**
Senior Geologist

/s/ Nick D. Skoularikis ***05/15/02***
Nick D. Skoularikis **Date**
Director of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	02/20/90	
001-005	-	No record.
006	12/31/01	Updated to reflect new SOP format. Minor revisions throughout.
007	05/15/02	Revised sections 4.5.3 (plastic sheeting) and 4.9.2 (boring abandonment with bentonite clay-grout).

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Hand Auger Borings

1. Purpose and Scope

This section discusses procedures for conducting hand auger soil borings either for exploration or for the installation of monitoring wells. The procedures provided in this text outline the advancement, decontamination, abandonment, and required documentation for the completion of hand auger borings. This document was prepared in accordance with ASTM D 1452 - 80. Soil sampling for chemical analysis is covered under the *Loureiro Engineering Associates, Inc. (LEA) Standard Operating Procedure (SOP) for Soil Sampling.*

2. Definitions

Hand auger: a stainless steel bucket attached to a handle with flights on the tip used to dig auger manually into the soil. A hand auger is used for shallow soil borings for which a drill rig would be impractical or time consuming. A hand auger may also be preferable at locations where utilities are suspected to be present.

3. Equipment

3.1. Equipment required for conducting hand auger boring includes:

- Hand auger (bucket or dutch).
- Auger extensions, wrenches, and handle.
- Hand towels.
- Portable VOC analyzer (Photovac MicroTIP® or equivalent).
- Polyethylene plastic sheeting.
- Distilled water.
- Field documentation.
- Indelible marker.
- Alconox® detergent, methanol, hexane, nitric acid.
- Three 5-gallon buckets.
- Analytical balance (accurate to 0.1 gram).
- 500 ml disposable beakers.
- Decontamination brushes.

- Personal protective equipment.
- Clipboard.
- Pry bar.

4. Procedure

4.1. Utilities

4.1.1. Notify the appropriate "one call" utility notification service (e.g. Call Before You Dig at 1-800-922-4455, Contractor ID: 10502) at least three working days prior to commencing operations on a site. The locations of all proposed borings must be clearly marked in the field prior to notification. The Project Engineer/Manager **must** call and confirm that each utility has been to the site and has marked their respective lines.

4.1.2. On private sites, consult with the Owner or other person knowledgeable about the site as to the locations of potential private or abandoned utilities and locate these prior to beginning work. Upon the discretion of the Project Engineer/Manager, a pipe locator can also be used to assist in locating utilities.

4.1.3. Note that OSHA may have additional requirements for location of utilities.

4.1.4. All efforts to locate underground utilities (including names of owner or designee and time) should be properly documented in the field logbook prior to onset of the work scheduled.

4.2. OSHA

4.2.1. The Senior LEA representative shall be the Competent Person required by OSHA for all work. However, this does not relieve other LEA representatives from bringing to his or her attention conditions, which may be unsafe or present a hazard to the drilling crew, the general public, or other workers on the site.

4.3. Water

4.3.1. Water is occasionally required to maintain the stability of the boring. If water is used, the source(s), quality, and volume(s) will be recorded on the boring log.

4.3.2. No other drilling fluid may be used without specific authorization from the Project Manager.

4.4. VOC Monitoring

4.4.1. A portable volatile organic compound (VOC) analyzer equipped with a photoionization detector (PID) or flame ionization detector (FID) shall be available on site and shall be used to screen all cuttings and fluids (if any) removed from the hole.

4.4.2. Since, in general, it cannot be presumed that a site is clean, all cuttings and/or fluids that show a reading on the VOC analyzer above background shall be containerized or drummed, as appropriate, on the site. The cuttings and fluids should also be containerized when the presence of other contaminants is suspected. Section 4.8 provides additional information on management of potentially contaminated fluids and materials.

All project-specific health and safety requirements shall be addressed in the Site-Specific Health and Safety Plan for the site.

4.5. Site Preparation

4.5.1. A sufficient area shall be cordoned off to restrict access to the work area. This area shall be termed an "Exclusion Zone".

4.5.2. An equipment decontamination area shall be assembled within the exclusion zone.

4.5.3. The area adjacent to the proposed borehole shall be covered with 5-mil plastic sheeting (minimum area: 10 square feet). Soil cuttings shall be placed on the plastic sheeting to avoid contact with the surface of the ground.

4.5.4. All necessary personal protective equipment shall be donned.

4.5.5. Should flooring need to be breached for the advancement of the boring, coring of the floor will be conducted using a concrete coring saw and a wet-dry vacuum to prevent water and cuttings from moving beyond the immediate vicinity of the borehole.

4.5.6. Begin the boring by rotating and advancing the auger to the desired depth. Remove the auger and examine the soil for texture, composition, density, moisture and grain-size distribution. Record all information as described in Section 4.7.

4.5.7. The soils removed shall be logged in two-foot increments or at each lithologic change.

4.5.8. Collect a sufficient aliquot of the soil sample to satisfy all requirements for field and laboratory analysis. A lithologic sample may be required and should be collected in a 4-ounce soil jar. The procedures for collection of soil samples for chemical analysis are described in *LEA SOP for Soil Sampling*. Discard boring spoils into the appropriate containers or onto the plastic sheeting for later disposal.

4.5.9. The portable organic vapor analyzer used to detect VOCs shall be a Photovac MicroTIP® photoionization detector or equivalent and calibrated in accordance with the instrument's instructions. Calibration shall be performed, at a minimum, prior to each sampling event and checked after each day of sampling.

4.5.10. The following procedure shall be used to obtain readings of the VOCs present in a soil sample:

1) Obtain an aliquot of soil (approximately 50 grams) from the bottom of the auger and place it into a Ziploc® plastic bag or equivalent and seal.

2) Agitate the sample, assuring that all soil aggregates are broken, for two minutes.

3) Carefully break the seal of the bag enough to insert the VOC probe. Care should be taken not to absorb any soil particles or liquids.

4) Record the maximum reading obtained on the appropriate forms.

4.6. Decontamination

4.6.1. All down-hole and sampling equipment will be sufficiently decontaminated prior to use. Decontamination procedures presented in site-specific work plans may vary slightly from those presented below, dependent upon the particular types of contaminants encountered.

4.6.2. A section of 5-mil plastic sheeting shall be cut of sufficient size to underlie the decontamination area to contain any discharge of decontamination solutions.

4.6.3. The following solutions (as appropriate for the anticipated contaminants) shall be prepared and placed in 500-ml laboratory squirt bottles: methanol solution (less than 10% solution); 10% nitric acid

solution; 100% hexane solution; and distilled deionized (DI) water. A fifth solution of phosphate-free detergent and tap water (approximately 2.5 gallons) shall be prepared in a five-gallon bucket.

4.6.4. All loose debris shall be removed from the augers and spatulas into an empty 5-gallon bucket or plastic sheeting, using a stiff bristled brush.

4.6.5. The order of decontamination solutions is as follows:

1) Detergent Scrub.
2) DI Water Rinse.
3) Hexane Rinse (to be used only if separate-phase petroleum product, other than gasoline, is present).
4) DI Water Rinse.
5) 10% Nitric Acid Rinse (to be used only when metals are suspected as potential contaminants).
6) DI Water Rinse.
7) Methanol Rinse (<10% solution).
8) Air Dry.

Prior to installing each boring and at the end of the project day, all used equipment shall be decontaminated. Containerize and dispose of all spent decontamination solutions in accordance with all applicable municipal, state and federal regulations.

4.7. Field Documentation

4.7.1. The following general information shall be recorded in the field log book and/or the appropriate field form(s).

- Project and site identification.
- LEA commission number.
- Field personnel.
- Name of recorder.
- Identification of borings.
- Collection method.
- Date and time of collection.
- Types of sample containers used, sample identification numbers and quality assurance/quality control (QA/QC) sample identification.
- Field analysis method(s).
- Field observations of sampling event.
- Name of collector.

- Climatic conditions, including air temperature.
- Chronological events of the day.
- Status of total production.
- Record of non-productive time.
- QA/QC data.
- Location of boring(s) on site in sufficient detail to relocate boring at a future time (include sketch).

4.7.2. The following information shall be recorded on the boring log:

- Project name, location, and LEA commission number.
- Borehole number, borehole diameter, boring location, drilling method, field crew performing work, groundwater observations, logger's name and date.
- Depth below grade, sample I.D. number, duplicate numbers, VOC analyzer reading.
- A complete sample description, including as a minimum: depth, material size gradation using the Burmister system, color, moisture, and density.
- Should a well be constructed in a bore hole, a complete well schematic shall be drawn and accurately labeled.

4.8. Disposal of Potentially Contaminated Materials

4.8.1. Potentially contaminated cuttings or fluids, as indicated by knowledge of the site, discoloration, VOC analyzer readings, or other evidence, shall be containerized on the site pending sampling and determination of hazardous waste status.

4.9. Boring Abandonment

4.9.1. If the boring is not to be used for other purposes (i.e. monitoring well, soil vapor probe, soil vapor extraction well, etc.), it shall be abandoned.

4.9.2. The boring shall be filled and sealed with a high-density bentonite clay grout.

4.9.3. Excess cuttings shall be containerized and sampled before disposal.

4.9.4. In paved areas, the upper three feet of the borehole shall be filled, up to two inches below the existing grade, with sand to allow for repairing of the pavement.

4.9.5. Pavement shall be repaired using cold patch asphalt filler or concrete.

5. Quality Assurance/Quality Control

5.1. All procedures documented in this SOP should be conducted to ensure quality and in accordance with LEA's *Standard Operating Procedure for Quality Assurance/Quality Control Measures for Field Activities* (SOP ID 10005)

6. References

None

END OF DOCUMENT

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Soil Sampling

SOP ID: 10006
Date Initiated: 02/20/90
Revision No. 009: 01/18/06

Approved By: _____ *01/18/06*
David Brisson **Date**
Senior Project Geologist

_____ *01/18/06*
Nick D. Skoularikis **Date**
Director of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	02/20/90	
001-004	-	No record.
005	07/19/00	Revisions to template, including new logo.
006	05/16/01	Revisions to Sections 4.2.1, 4.2.2; add Section 4.2.3.
007	07/27/01	Updated to conform with new SOP format.
008	12/31/01	Minor revisions throughout.
009	01/18/06	Removed use of wood spatula

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Soil Sampling

1. Purpose and Scope

This document discusses procedures for collection of soil samples for analysis. Methods for collection and quality assurance/quality control (QA/QC) requirements are covered under separate standard operating procedures (SOPs). The procedures outlined in this document are in accordance with American Society of Testing Materials (ASTM) Standard D 420 and the Environmental Protection Agency (EPA) document entitled, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846). These procedures may vary slightly according to project-specific requirements.

2. Definitions

2.1. Field Forms: For the purpose of document and data control, a form is a document used in the conduct of company business to collect data, including approvals where required. Completed forms providing objective evidence of quality related activities are retained as quality records.

3. Equipment

3.1. Equipment required for the collection of soil samples shall include:

- Stainless steel spatula.
- Decontamination solutions, including distilled water, 10 percent methanol, 10 percent nitric acid.
- Hand towels.
- Polyethylene plastic sheeting.
- Sample collection jars.
- Clean disposable gloves.
- Field documentation.
- Indelible ink marker.
- Cooler, cold packs.
- Chain of custody seals and sample labels.
- Balance for weighing samples (for samples collected for the Loureiro Engineering Associates, Inc. (LEA) Analytical Laboratory, if needed).
- Utility knife.

- Re-sealable plastic bags.

4. Procedures

4.1. Preliminary Sampling Procedures

4.1.1. Sample Bottles

4.1.1.1. A laboratory request form shall be completed and submitted to the laboratory with the following information:

- Project name.
- LEA commission number.
- Date of submittal and date needed.
- Quantity of sample locations and sample points at each location.
- Type(s) of samples.
- Analytes, detection limits and QA/QC needed.
- Cooler(s) required.
- Number of chain of custody forms requested.

4.1.1.2. Check bottles against laboratory request form for completeness. The bottles should also be checked for damage and cleanliness. Confirm with laboratory personnel the adequacy of the preservatives used.

4.1.1.3. The total number of sample sets shall be increased by 10 percent to allow for possible breakage during transport to sites or other contingencies. At a minimum one additional sample bottle set shall be obtained per event.

4.1.1.4. Obtain preprinted labels and paperwork through the LEA information management system.

4.1.1.5. Label/date bottles in the field prior to sample collection. Check for accuracy.

4.1.1.6. A cooler with adequate ice or cold packs should be obtained from the laboratory to insure that the collected samples remain at 4 degrees Celsius during transport. Packing material should also be obtained to insure against breakage during transport.

4.1.2. Site Preparation

4.1.2.1. A level table shall be placed within the exclusion zone and covered with polyethylene sheeting.

4.1.2.2. Decontaminated spatulas shall be placed on the table. Sample bottles shall be placed in a convenient location and in order of sample collection.

4.1.2.3. PID and plastic bags shall be placed on the table for VOC screening, if necessary.

4.2. Cleaning and Decontamination

4.2.1. Prior to collecting a soil sample, the LEA representative will ensure that all necessary sampling equipment is clean and decontaminated according to the procedure outlined in Section 4.2.3 or according to the site specific work plan if different than below.

4.2.2. Upon completion of all sampling requirements and prior to leaving the site, all equipment used for sampling shall be cleaned and decontaminated according to the procedure outlined in Section 4.2.3 or according to the site specific work plan if different than below. All generated decontamination fluids shall be containerized and disposed of in accordance with the site-specific work plan and all municipal, state, and federal requirements.

4.2.3. The decontamination procedure of durable sampling equipment will be accomplished via swabbing the surfaces with a solvent. The order of decontamination is as follows:

- Detergent swab.
- DI water rinse.
- Hexane rinse (to be used if separate-phase petroleum product, other than gasoline is present).
- DI water rinse.
- 10 percent nitric acid rinse (to be used only when metals are suspected as potential contaminants).
- DI water rinse.
- Methanol rinse (less than 10 percent solution).
- Air dry.

4.3. Sampling Procedures

4.3.1. All personal protective equipment (PPE) should be donned and maintained in accordance with the site-specific work plan or health and safety plan during all sampling procedures. In the event that no PPE has been specified for a particular sampling event, disposable latex gloves should be donned, as a minimum, during all sampling procedures.

4.3.2. The particular soil sampling device (i.e., hand auger, split spoon, etc.) shall be retrieved from the point of collection and placed on a level table covered in polyethylene sheeting.

4.3.3. Using a decontaminated stainless steel spatula, the soil shall be transferred directly into soil sampling containers. Care should be taken to completely fill the sample container intended for VOC analysis. Large void spaces within the container shall be minimized by packing, not agitation.

4.3.4. Wipe the rim of the sample container with a clean paper towel to remove excess solids, which would prevent adequate sealing of the sample container and seal the container.

The order of sample collection shall be as follows:

- Samples to be analyzed for volatile organic compounds (VOCs) at the LEA Analytical Laboratory.
- Samples to be analyzed for VOCs using appropriate EPA methodologies.
- Samples to be screened for total VOCs with a total volatile organic analyzer.
- Samples to be analyzed for other organic and inorganic constituents.

4.3.5. As required, affix a custody seal, noting the date and time of collection across the cap/bottle interface and on the sample label. Place and secure sample within cooler and complete all sample collection documentation. Alternatively, a custody seal shall be used to seal the entire cooler rather than individual sample containers.

4.4. Post Sampling Procedures

4.4.1. As required, upon completion of all sampling procedures for a particular site, secure the lid of the cooler using packaging tape with the chain of custody inside.

4.4.2. If the laboratory is local, transport the samples directly to the laboratory and present them to the sample manager. The representative of LEA should witness the verification of the chain of custody and obtain a carbon copy for filing in the project notebook.

4.4.3. If the laboratory is distant, arrange for transport with a reputable carrier service. Typically, the laboratory specifies the carrier to be used and provides the shipping papers. The cooler and samples shall be secured for transport, and all mailing documentation secured onto the top of the cooler. Unless otherwise specified, delivery shall be overnight. Friday shipments should be mailed for Saturday delivery, once confirmed that the laboratory can accept them on Saturday. The laboratory shall provide confirmation of acceptance noting the temperature of the temperature blank and any deviations from the chain of custody.

4.5. Documentation

4.5.1. The following general information shall be recorded in the field log book and/or on the appropriate field forms:

- Project and site identification.
- LEA commission number.
- Field personnel.
- Name of recorder.
- Identification of borings.
- Collection method.
- Date and time of collection.
- Types of sample containers used, sample identification numbers and QA/QC sample identification.
- Preservative(s) used.
- Parameters requested for analysis.
- Field analysis method(s).
- Field observations on sampling event.
- Name of collector.
- Climatic conditions, including air temperature.
- Internal temperature of field and shipping (cooled) containers.

- Chronological events of the day.
- Status of total production.
- Record of non productive time.
- QA/QC data.

4.5.2. The following information shall be recorded on the Daily Field Report QA Checklist:

- Reviewer's name, date, and LEA commission number.
- Review of all necessary site activities and field forms.
- Statement of corrective actions for deficiencies.

4.5.3. The following information shall be recorded on the chain of custody record:

- Client's name and location.
- Date and time of sample collection.
- Sample number.
- Container type, number, size.
- Preservative used.
- Signature of collector.
- Signatures of persons involved in the chain of possession.
- Analyses to be performed.
- Type and number of samples.

4.5.4. The following information shall be provided on the sample label using an indelible ink pen:

- Sample identification number.
- Date and time of collection.
- Place of collection.
- Parameter(s) requested (if space permits).

4.5.5. The following information shall be recorded on the sample collection data sheet:

- Client name, location and LEA commission number.
- Boring or sampling location identification number.
- Date and time of collection.
- Sample number.
- Depth sample was obtained.
- Field instrumentation reading.

5. Quality Assurance/Quality Control

5.1. One trip blank sample should accompany the sampling set for each field crew and each field day for which VOC samples are collected.

5.2. One equipment blank sample should be collected for each field crew and each field day. Equipment blank samples should be analyzed for the same suite of analytes as the soil samples.

5.3. For QA/QC purposes, one duplicate sample will be collected for every twenty samples. The duplicate sample set will be analyzed for the same suite of analytes as the soil samples.

6. References

6.1. ASTM Standard D 420

6.2. EPA, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846).

END OF DOCUMENT

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

SOP ID: 10015
Date Initiated: 12/27/94
Revision No. 002: 01/15/02

Approved By: */s/ Kimberly C. Clarke* *01/15/02*
Kimberly C. Clarke **Date**
Senior Project Scientist

/s/ Nick D. Skoularikis *01/15/02*
Nick D. Skoularikis **Date**
Director Of Quality

REVISION RECORD

Rev #	Date	Additions/Deletions/Modifications
Initial Issue	12/27/94	
001	11/20/96	No record
002	01/15/02	Formatting and minor revisions throughout

Loureiro Engineering Associates, Inc.
Standard Operating Procedure
for
Geologic Logging of Unconsolidated Sedimentary Materials

1. Purpose and Scope

This document presents the methods and procedures used to describe unconsolidated sedimentary materials for geological purposes in a uniform and consistent manner. It includes procedures for properly recording the observations by providing guidelines for completing boring logs and submitting those logs for computer entry. This Standard Operating Procedure (SOP) refers only to geologic logging of soils and sediments (including artificial fill and other man-made deposits) and specifically is not intended to describe logging of soils or sediments for geotechnical or other engineering purposes. Although the SOP presents a system for describing sediments, it is not intended to be a definitive reference for classifying sedimentary materials, nor is it intended to replace experience or training. Individuals using this SOP should be trained and competent in field methodologies and geologic logging prior to commencing field activities.

2. Definitions

2.1. None

3. Equipment

3.1. Equipment required for the geologic logging of soil/sediment samples shall include the following items:

- Tape measure or scale.
- Hand lens.
- Color chart.
- Grain-size comparator.
- Field forms.
- Indelible marker(s).
- Small table.
- Field Paperwork.
- Clipboard.

4. Procedures

4.1. Sample Collection

Samples of soil and unconsolidated sedimentary materials will be collected in general accordance with the SOPs for Soil Sampling (SOP ID 10006), Hand Auger Borings (SOP ID 10003), Hollow Stem Auger Soil Borings (SOP ID 10008), and Geoprobe® Probing and Sampling (SOP ID 10011). Those SOPs include procedures for decontamination of equipment required for sample collection, as well as providing the methodologies for sample collection and documentation.

4.2. Descriptions of Unconsolidated Sedimentary Materials

4.2.1. General Sediment Description Guidelines

For the purposes of geologically logging unconsolidated soils and sedimentary materials, a Modified Burmister method of description and classification should be used. The Modified Burmister Sediment Classification System (or simply, Burmister System) is intended as a rapid field method for identifying and classifying sediments. The system is based upon visual identification of the generalized grain-size distribution and description of the physical characteristics of the sample.

A Burmister System description is comprised of three parts: a color descriptor; a grain-size descriptor; and modifier(s). The color descriptor indicates the overall color or colors of the wet sample. The descriptor consists of a color name or names and (if possible) the color code from a standard color reference (for example, a Munsell[7] Color Chart). The grain-size description indicates the predominant grain size in the sample, as well as the relative percentages of other grain sizes present.

Modifiers are used to further describe the geologic character of the sample. Modifiers may include descriptions of moisture content, sorting, sphericity, angularity, sedimentary structures or other pertinent information.

4.2.2. Color Description

The color of the wet sediment should be determined with reference to a standard color comparator (for example, a Munsell[7] Color Chart) for rocks or sediment. The included color descriptor should contain both the color name and, when a color comparator is used, the appropriate hue-chroma value code, for example "Reddish brown (5YR 4/4)". The color of a sample should always be gauged when the sample is wet, or it should be noted otherwise.

4.2.3. Predominant Grain-Size Description

The first step in describing a sediment sample is visually estimating the size range and percentage of the various grain sizes in the sample. Reference should be made to standard geologic comparators for assessment of the grain size(s).

The primary grain-size descriptor indicates the predominant grain size, as judged visually, of the sample. The descriptor is always capitalized and underlined. Possible descriptors include: CLAY, SILT, SAND, and GRAVEL (GRANULES, PEBBLES, COBBLES, and BOULDERS). These correspond to the standard Wentworth size-classification scheme used for describing sediments for geologic purposes. Size classifications for CLAY through GRAVEL are presented in Table 1. The descriptor should also include an indication of the relative size range of the sample within the predominant grain size (for example, "fine-to-medium sand", "coarse sand", etc.). Although Table 1 includes divisions of the silt category, this is applicable only to sediment samples analyzed by pipette or hydrometer and cannot be distinguished in the field.

The presence of other grain sizes, in addition to the predominant material is also included in the grain-size descriptor. Appropriate grain sizes are the same as for the predominant grain size of the material (clay, silt, etc.), however only the initial letter of the word is capitalized. The description should also include an indication of the relative amount of the minor components. Appropriate indicators for the relative percentages present are provided in Table 2.

It is generally not considered possible to visually distinguish between clay and silt. Estimation of the silt/clay content of a sample should be based upon the plastic properties of the sample. The plastic properties of the sample may be estimated by taking an approximately 1 cubic centimeter ball of the sediment and attempting to roll a thread of the material between the palms of the hand. The minimum size of the thread which may be rolled may be compared to the values presented in Table 3 and the plasticity estimated. A comparison of the minimum thread diameter which may be formed with the information presented in Table 3 provides an approximate silt/clay content estimate for sand-silt-clay sediments and composite clay sediments.

4.2.4. Modifiers

Various modifiers may be added to the basic sediment description to further describe the geologic character of the sample.

For sand or coarser-sized material, the relative degree of sorting, the sphericity, and angularity should also be recorded. Sorting may be visually estimated. Sphericity and angularity, however, should be made with reference to an accepted comparator. A chart illustrating various degrees of sphericity and angularity is attached as Figure 1.

The mineralogy of the sample should also be recorded. Reference should be made to the relative percentages, grain size(s), and sphericity of the mineral particles (especially where it differs significantly from that of the predominant grain-size material).

Other information which should be recorded for each sample includes an estimate of the density and cohesiveness of the sample (made from blow counts where applicable, or other specific instrumentation where appropriate), the relative moisture content of the sample, visible sedimentary structures, and any odors or staining noticeable during logging. Tables 3 and 4 present appropriate terms for describing the plasticity, density, and cohesiveness of sediment samples.

Especially important is an indication that a specific portion of the material may represent "sluff" or material collapsed from the borehole walls.

4.3. Written Sediment Descriptions

The written sediment description may be made as either an unabbreviated or an abbreviated description. Both methods should relate the same information, however the abbreviated description is better suited for field use.

In an unabbreviated description, all of the words of the description should be written out in their entirety. The descriptor should include pertinent information regarding the sample's size gradation, consistency, color, and relative grain size, as described previously. The color descriptor should precede the primary sediment component name, while additional details such as the plasticity, mineralogy, visible sedimentary structures, etc., should follow the sediment component name.

An example of an unabbreviated description is:

Red-brown (5YR 4/4), fine to coarse SAND, little fine Gravel, little Silt, moist, moderately well sorted, low sphericity, Gravel waterworn, Sand subangular, micaceous.

Since the Burmister system is intended to provide a means for describing uniform sediments, three "special" cases should be addressed.

First, the Burmister system is intended only to describe the sediment. Where a genetic classification of the material is significant, it should be added as a separate statement at the end of the description. For example:

> **Olive gray (5Y 4/2), coarse to fine SAND, some fine Gravel, little Silt, moist, poorly sorted, sub-rounded to angular, dense. TILL.**

A genetic classification should only be used when the origin of the material is very clear and not simply a field interpretation of possible depositional environment.

Second, in the case where the sediment sample is heterogeneous (for example, a varved silt and clay), each component should be described individually, and reference should be made to the relative percentages of each component and to the interlayering. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY and SILT, alternately layered, medium to high overall plasticity. Layers: CLAY layers, 3/8" to 5/8" thick, comprise 60%" of sample. SILT layers, 1/8" to 3/8" thick, comprise 40%" of sample. VARVED CLAY and SILT.**

Third, when one material grades uniformly into a distinct sediment type, the individual components should be described separately and the gradation noted. For example:

> **Soft, reddish-brown (5YR 3/4), CLAY, medium overall plasticity, grading into soft, reddish-brown (5YR 4/4), SILT, trace Clay, low overall plasticity.**

In the abbreviated sediment descriptions, the sample information is presented in a manner analogous to that for the unabbreviated description substituting standard abbreviations for specific portions of the text. Abbreviations for the identifying terms in the Burmister system are presented in Tables 2, 3, and 4. Mineralogic and geologic abbreviations may be found in standard geologic and mineralogic texts and field manuals. Except for the use of abbreviations, the abbreviated description is completely analogous to the unabbreviated description.

For the sake of consistency in describing unconsolidated sedimentary materials, the description should follow the order and general definitions presented in Table 5.

4.4. Recording Descriptions

4.4.1. Geologic Boring Logs

Attached to this SOP is a copy of LEA's standard geologic boring log form. This log should be completed for each boring that is completed. The heading information is self-explanatory. The body of the log contains space for information for each sampled interval in the boring. The following information should be recorded:

Depth Interval	The upper and lower depths from which the sample was collected.
Sample No.	The sample number, as obtained from LEA Data Management, assigned to this sample.
Recovery	The length of the recovered sample and the length of the sampler (in consistent units). The percent recovery will be calculated by the LEA Data Management program.
Blows/6"	The number of blow counts per 6" interval for the sample. Alternately, the downhole pressure or other pertinent information regarding the required drilling or sampling force.
Sample Description	The sample description using the guidelines and order presented in Section 3.0 and Table 5.
PID/FID	The headspace reading from a PID or FID in ppm.

The comments section of the form should be used to record general observations regarding drilling conditions, backfilling of the borehole, or other pertinent information regarding drilling the borehole.

4.5. Computer Data Entry

After a project is completed, copies of the Geologic Boring Log forms should be submitted for computer data entry. A completed copy of the Geologic Soil Boring/well Completion Log Request Form should be attached to the log forms.

5. Quality Assurance/Quality Control

5.1. Soil and sediment logging will be conducted in accordance with this SOP to ensure quality and consistency in field activities.

5.2. Field paperwork will be reviewed by office staff personnel and/or project manager to ensure completeness and accuracy in logging records.

6. References

6.1. None

END OF DOCUMENT

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification	
Use Wire Squares	4096	4,096,000	-20	Boulder	GRAVEL
	1024	1,024,000	-10		
	256	256,000	-8		
				Cobble	
	64	64,000	-6		
				Pebble	
	16	16,000	-4		
5	4	4,000	-2		
				Granule	
6	3.36	3,360	-1.75		
7	2.83	2,830	-1.50		
8	2.38	2,380	-1.25		
10	2.0	2,000	-1.00		
				Very Coarse Sand	SAND
12	1.68	1,680	-0.75		
14	1.41	1,410	-0.50		
16	1.19	1,190	-0.25		
18	1.00	1,000	0.00		
				Coarse Sand	
20	0.84	840	0.25		

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification
25	0.71	710	0.50	
30	0.59	590	0.75	
35	0.50	500	1.00	
				Medium Sand
40	0.42	420	1.25	
45	0.35	350	1.50	
50	0.30	300	1.75	
60	0.25	250	2.00	
				Fine Sand
70	0.210	210	2.25	
80	0.177	177	2.50	
100	0.149	149	2.75	
120	0.125	125	3.00	
				Very Fine Sand
140	0.105	105	3.25	
170	0.088	88	3.50	
200	0.074	74	3.75	

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification	
230	0.0625	62.5	4.00		
				Coarse Silt	MUD
270	0.053	53	4.25		
325	0.044	44	4.50		
Analyzed by Pipette or Hydrometer	0.037	37	4.75		
	0.031	31	5.0		
				Medium Silt	
	0.0156	15.6	6.0		
				Fine Silt	
	0.0078	7.8	7.0		
				Very Fine Silt	
	0.0039	3.9	8.0		
				Clay (Note: Some use 2: (or 9N) as the clay boundary.)	
	0.0020	2.0	9.0		
	0.00098	0.98	10.0		
	0.00049	0.49	11.0		
	0.00024	0.24	12.0		
	0.00012	0.12	13.0		

TABLE 1
Wentworth Size Classification System

US Standard Sieve Sizes	Millimeters	Microns	Phi (N)	Wentworth Size Classification
	0.00006	0.06	14.0	

Table 2
Modified Burmister System Descriptors

Fractions		Proportion Descriptors		
(+)	Major Fraction	Quantity	Descriptor	Abbreviation
(-)	Minor Fraction	35% - 50%	and	a
e.g., a medium to coarse SAND which is predominantly medium grained would be written as: m(+) - c SAND		20% - 35%	some	s
		10% - 20%	little	l
		1% - 10%	trace	t
		Modifiers: (+) Upper a of the range (-) Lower a of the range		

Table 3
Plasticity of Sediment Samples

Material	Symbol	Feel	Ease of Rolling Thread	Minimum Thread Diameter	Plasticity Index	Plasticity
Clayey SILT	CyM	Rough	Difficult	1/4"	1 to 5	Slight (Sl)
SILT & CLAY	M & C	Rough	Less Difficult	1/8"	5 to 10	Low (L)
CLAY & SILT	C & M	Smooth, dull	Readily	1/16"	10 to 20	Medium (M)
Silty CLAY	MyC	"Shiny"	Easy	1/32"	20 to 40	High (H)
CLAY	C	Waxy, very shiny	Easy	1/64"	40 +	Very High (VH)

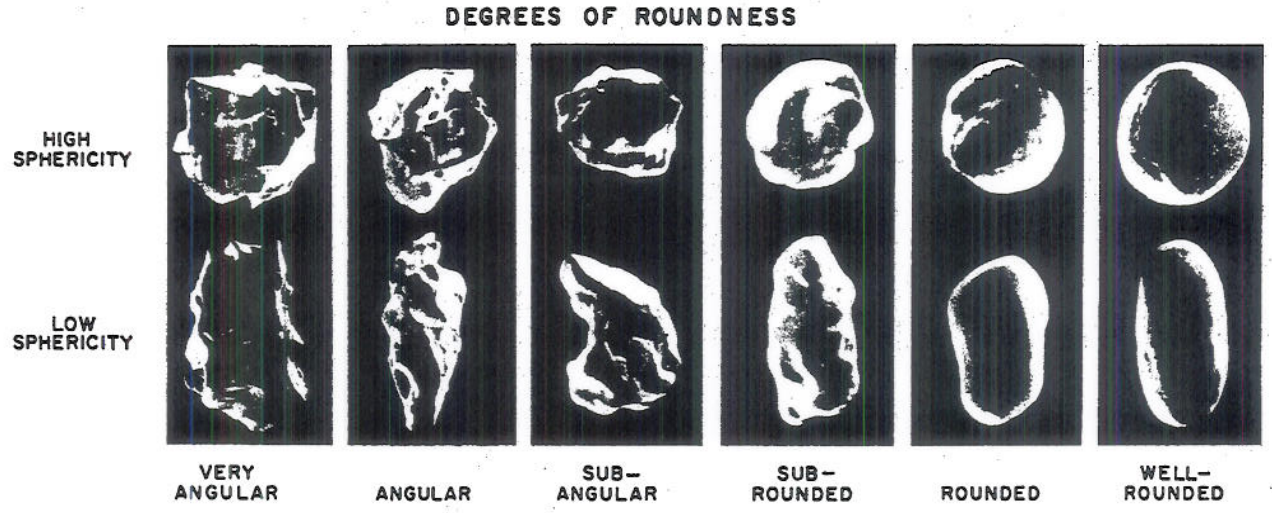
Table 4
Density and Cohesiveness of Sediment Samples

Density of Cohesionless Soils		Consistency of Cohesive Soils	
Blow Counts	Relative Density	Blow Counts	Consistency
0 to 4	Very Loose	0 to 2	Very Soft
5 to 9	Loose	2 to 4	Soft
10 to 29	Medium Dense	4 to 8	Medium
30 to 49	Dense	8 to 15	Stiff
50 to 79	Very Dense	15 to 30	Very Stiff
80 or more	Extremely Dense	30 or more	Hard

Table 5
Description of Sediment Properties

Sediment Parameter	Properties
Color	The color of the sample should be described for the wet sediments. If possible the color should be referenced to a standard color chart such as a Munsell7 Color Chart.
Primary Grain Size	Primary grain size refers to the size of the predominant sedimentary size class within the material (as judged visually). The grain size divisions should conform to the standard Wentworth Scale divisions, as shown in Table 1.
Secondary Grain Size(s)	Secondary grain size(s) refer to material which, as a grain-size group, comprises less than the majority of the sediment. Aside from stating the size classification, the relative percentage of the material must be stated. The grain size divisions should conform to the standard Wentworth Scale divisions as shown in Table 1. To describe the approximate percentage of the secondary grain size(s) present, qualifiers shown in Table 2 should be used.
Moisture Content	The moisture content of the sample should be described as dry, slightly moist, moist, or wet. Gradation from one state to another should be recorded as, for example, moist to wet, or moisty wet.
Sorting	The relative degree of sorting of the sediment should be indicated as poor, moderate, good, or very good. The degree of sorting is a function of the number of grain size classes present in the sample; the greater the number of classes present the poorer the sorting. In addition, for samples composed only of sand, the relative degree of sorting is a function of the number of sand-size subclasses present.
Sphericity	Sphericity is a measure of how well the individual grains, on average, approximate a sphere. The average sphericity of the sand and larger size fractions should be described as low, moderate or high. A chart illustrating various degrees of sphericity is presented in Figure 1.
Angularity	Angularity, or roundness, refers to the sharpness of the edges and corners of a grain (or the majority of the grains). Five degrees of angularity are shown in Figure 1: Angular (sharp edges and corners, little evidence of wear); Subangular (edges and corners rounded, faces untouched by wear); Subrounded (edges and corners rounded to smooth curves, original faces show some areas of wear); Rounded (edges and corners rounded to broad curves, original faces worn away); and, Well Rounded (no original edges, faces, or curves, no flat surfaces remain on grains).
Sedimentary Structures	Sedimentary structures are such things as varved layers, distinct bedding, or stratification.
Density -or- Cohesiveness	The density of cohesion of a sample (for the purposes of this application) refer to the sample's resistance to penetration by a sampling device. Density is used in reference to sediments primarily silt-size and coarser while cohesiveness is used in reference to primarily clay-sized sediments. Density or cohesiveness can be assessed from the number of blows from "standard" split-spoon sampling (i.e., 140# hammer, 30" fall, 2" X 2" (O.D., 1 3/8" I.D.)) split-spoon samplers according to the scale in Table 3.

FIGURE 1



SPHERICITY

0.3	LOW
0.5 & 0.7	MODERATE
0.9	HIGH

ROUNDNESS

0.1	ANGULAR
0.3	SUBANGULAR
0.5	SUBROUNDED
0.7	ROUNDED
0.9	WELL ROUNDED